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SERIAL No. .....

HANDBOOK
OF
MAINTENANCE INSTRUCTIONS
FOR
TS-56A/AP EQUIPMENT

CONFIDENTIAL

★

Published under joint authority of the United States War and Navy Departments and the Air Council of the United Kingdom.

★

FAILURE REPORT

FOR U.S. ARMY AIR FORCE PERSONNEL

UNSATISFACTORY REPORT

In the event of malfunctioning, unsatisfactory design or unsatisfactory installation of any of the component units of this equipment, or if the material contained in this book is considered inadequate or erroneous, an Unsatisfactory Report, AAF Form No. 54 or a report in similar form shall be submitted in accordance with the provisions of Army Air Force Regulation No. 15-54, listing:

1. Station and organization.
2. Nameplate data (type number or complete nomenclature if nameplate is not attached to the equipment).
3. Date and nature of failure.
4. Airplane model and serial number.
5. Remedy used or proposed to prevent recurrence.
6. Handbook errors or inadequacies, if applicable.

FOR U.S. NAVY PERSONNEL

Report of failure of any part of this equipment during its guaranteed life shall be made on Form N. Aer. 4112, "Report of Unsatisfactory or Defective Material" or a report in similar form and forwarded in accordance with latest instructions of the Bureau of Aeronautics. In addition to other distribution required, one copy shall be furnished to the Inspector of Naval Material (location to be specified) and the Bureau of Ships. Such reports of failure shall include:

1. Reporting activity.
2. Nameplate data.
3. Date placed in service.
4. Part which failed.
5. Nature and cause of failure.
6. Replacement needed (yes-no).
7. Remedy used or proposed to prevent recurrence.

FOR BRITISH PERSONNEL

Form 1022 procedure shall be used when reporting failure of radio equipment.

CONTRACTUAL GUARANTEE

The equipment, including all parts and spare parts, except vacuum tubes, batteries, rubber and material normally consumed in operation, is guaranteed for a period of one year from the date of delivery of the equipment to and acceptance by the Government with the understanding that all such items found to be defective as to material, workmanship or manufacture will be repaired or replaced, f.o.b. any point within the continental limits of the United States designated by the Government, without delay and at no expense to the Government; provided that such guarantee will not obligate the Contractor to make repair or replacement of any such defective items unless the defect appears within the aforementioned period and the Contractor is notified thereof in writing within a reasonable time and the defect is not the result of normal expected shelf life deterioration.

To the extent the equipment, including all parts and spare parts, as defined above, is of the Contractor's design or is of a design selected by the Contractor, it is also guaranteed, subject to the foregoing conditions, against defects in design with the understanding that if ten per cent (10%) or more of any such said item, but not less than two of any such item, of the total quantity comprising such item furnished under the contract, are found to be defective as to design, such item will be conclusively presumed to be of defective design and subject to one hundred per cent (100%) correction or replacement by a suitably redesigned item.

All such defective items will be subject to ultimate return to the Contractor. In view of the fact that normal activities of the Naval Service may result in the use of equipment in such remote portions of the world or under such conditions as to preclude the return of the defective items for repair or replacement without jeopardizing the integrity of Naval communications, the exigencies of the Service, therefore, may necessitate expeditious repair of such items in order to prevent extended interruption of communications. In such cases the return of the defective items for examination by the Contractor prior to repair or replacement will not be mandatory. The report of a responsible authority, including details of the conditions surrounding the failure will be acceptable as a basis for affecting expeditious adjustment under the provisions of this contractual guarantee.

The above one year period will not include any portion of time the equipment fails to perform satisfactorily due to any such defects, and any items repaired or replaced by the Contractor will be guaranteed anew under this provision.

FIRST AID

PERSONNEL ENGAGED IN THE INSTALLATION, OPERATION AND MAINTENANCE OF THIS EQUIPMENT OR SIMILAR EQUIPMENT ARE URGED TO BECOME FAMILIAR WITH THE FOLLOWING RULES, BOTH *IN THEORY AND IN THE PRACTICAL APPLICATION THEREOF.* IT IS THE DUTY OF EVERY RADIOMAN TO BE PREPARED TO GIVE ADEQUATE FIRST AID AND THEREBY PREVENT AVOIDABLE LOSS OF LIFE. YOUR OWN LIFE MAY DEPEND ON THIS.

Do These Three Things First in Any Emergency Requiring First Aid

1. Send for a doctor or carry the victim to a doctor.
2. Keep victim warm and quiet and flat on his back.
3. If breathing has stopped, apply artificial respiration. Stop all serious bleeding.

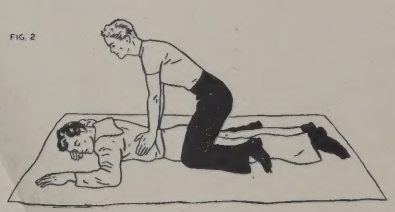
When, from any cause whatever, breathing has stopped, apply artificial respiration immediately and continue WITHOUT STOPPING until normal breathing returns, or a doctor pronounces the victim dead. SPEED IN BEGINNING ARTIFICIAL RESPIRATION IS ESSENTIAL.

The Prone Pressure Method of Artificial Respiration

If Due to Electric Shock

1. PROTECT YOURSELF with DRY insulating material.
2. BREAK THE CIRCUIT by opening the power switch or pulling the victim free of the live conductor. DON'T TOUCH THE VICTIM WITH YOUR BARE HANDS UNTIL THE CIRCUIT IS BROKEN.
3. SPREAD DRY BLANKET ON THE GROUND, and roll victim to center of blanket with his arms extended over his head, so that he lies FACE DOWN on blanket.
4. BEND ONE OF THE VICTIM'S ARMS at the elbow and rest victim's cheek on the back of his hand.
5. REMOVE FALSE TEETH, gum, candy, tobacco, food, etc. from victim's mouth.
6. LOOSEN ALL TIGHT CLOTHING, as belts or collars.
7. COVER VICTIM LOOSELY by wrapping the ends of the blanket around him.
8. STRADDLE VICTIM across thighs.
9. PLACE THE PALMS OF YOUR HANDS ON VICTIM'S BACK so that the little fingers of each hand just touch the victim's lowest ribs.

(1) Straddle victim across thighs. Place the palms of your hands on the victim's back so that the little fingers of each hand just touch the victim's lowest ribs.



(2) Keep your arms stiff and straight and swing your body forward, allowing your weight to bear down on victim. DO NOT PUSH OR USE FORCE.

(3) Swing back at once to relieve pressure and then continue the rhythmic application of alternate pressure and release.

Blanket is not shown in above drawings for the sake of clarity.

10. KEEP YOUR ARMS STIFF AND STRAIGHT and swing your body forward, allowing your weight to bear down on the victim.

11. DO NOT PUSH OR USE FORCE.

12. SWING BACK AT ONCE TO RELIEVE PRESSURE.

13. REPEAT Number 10.

14. REPEAT Number 12.

15. CONTINUE as above, maintaining a steady rhythm until victim regains consciousness or is pronounced dead by a doctor.

16. CONTINUE ARTIFICIAL RESPIRATION even after victim begins to breathe, and until he becomes conscious.

17. IF BREATHING STOPS AGAIN, continue artificial respiration at once.

18. DO NOT GIVE UP HOPE of reviving the victim. Four hours or more of continuous application of artificial respiration may be required before consciousness returns.

19. NEVER TRY TO FORCE LIQUIDS down an unconscious person's throat. He will drown.

20. ALWAYS WAIT UNTIL CONSCIOUSNESS RETURNS before administering liquid stimulants.

21. RECOMMENDED STIMULANTS ARE: Hot, black coffee. Strong, hot tea. Aromatic spirits of ammonia, one teaspoonful to a glass of water.

22. GIVE ONLY ONE STIMULANT, which should be sipped slowly.

23. ALCOHOLIC DRINKS are not recommended, unless absolutely nothing else is available.

24. WHEN VICTIM HAS RETURNED TO CONSCIOUSNESS, allow him to lie quietly where he is for at least one hour, taking care that he is well covered and free from worry.

25. IF POSSIBLE, CARRY, OR HAVE HIM CARRIED TO A DOCTOR.

WOUNDS

Neglected wounds can have serious consequences. Any break in the skin is a wound. Paint small cuts and scratches immediately with TINCTURE OF IODINE. Deep cuts and wounds should be KEPT CLEAN but DO NOT use Tincture of Iodine on them. Washing AROUND and AWAY FROM the wound with ordinary soap and water, if no other antiseptic is available, is recommended. Other antiseptics for use on deep wounds are: Violet gentian, Potassium permanganate, Tincture of Merthiolate, or ordinary baking soda and water. Cover the wound with a sterile gauze dressing and hold in place with adhesive tape or a strip of gauze.

In cases of serious bleeding, when an artery has been cut, firm pressure is necessary to stop the flow of blood. Arterial bleeding is BRIGHT RED and comes from the wound in SPURTS, with each beat of the heart. Bleeding from a vein is DARK RED and flows steadily. Pressure is not often needed for venous bleeding.

Pressure is applied ABOVE the wound, or between the WOUND AND THE HEART, to stop ARTERIAL BLEEDING. Pressure is applied BELOW the wound, or AWAY FROM THE HEART to stop VENOUS BLEEDING.

Pressure is best applied and maintained by means of a TOURNIQUET.

A TOURNIQUET is a strip of cloth, bandage, or other material, tied ABOVE the wound. Tie a simple, double knot in the cloth and place a strong stick or other rigid member in the loop thus made, then tighten the knot by pulling the ends of the cloth.

With the rigid member thus held firmly in place, twist it, until the bleeding stops.

DO NOT maintain such pressure longer than 15 minutes at a time.

IF BLEEDING CONTINUES after loosening tourniquet, allow the blood to flow for about 30 to 60 seconds and then re-apply pressure. Continue until bleeding stops.

AFTER BLEEDING HAS STOPPED, the wound should be carefully covered with a sterile dressing. DO NOT TOUCH WOUND OR DRESSING WITH DIRTY HANDS!

Keep the victim LYING FLAT ON HIS BACK, AND WELL COVERED. DO NOT LET HIM SEE HIS WOUND. Divert his thoughts from himself.

Obtain the services of a DOCTOR AS SOON AS POSSIBLE.

BURNS

Burns, whether caused by contact with high voltage electrical equipment, fire, or friction, require immediate attention.

1. Apply AT ONCE any one of the following:
   a. Tannic acid jelly.
   b. Butesin picrate.
   c. Paste made with baking soda and water.
   d. Very strong, cool tea.
2. Applications should be LIBERAL and the burned area covered with STERILE GAUZE.
3. If clothing sticks to the burned areas, DO NOT ATTEMPT TO REMOVE IT. Treat burn as above.
4. Keep the victim WELL COVERED and LYING FLAT ON HIS BACK. Soothe and reassure him.
5. Obtain the services of a DOCTOR AS SOON AS POSSIBLE.

DESTRUCTION OF ABANDONED MATERIEL IN THE COMBAT ZONE

In case it should become necessary to prevent the capture of this equipment and when ordered to do so, DESTROY IT SO THAT NO PART OF IT CAN BE SALVAGED, RECOGNIZED, OR USED BY THE ENEMY. BURN ALL PAPERS AND BOOKS.

Means:-

1. Explosives, when provided.
2. Hammers, axes, sledges, machetes, or whatever heavy object is readily available.
3. Burning by means of incendiaries such as gasoline, oil, paper, or wood.
4. Grenades and shots from available arms.
5. Burying all debris or disposing of it in streams or other bodies of water, where possible and when time permits.

Procedure:-

1. Obliterate all identifying marks. Destroy nameplates and circuit labels.
2. Demolish all panels, castings, switch- and instrument-boards.
3. Destroy all controls, switches, relays, connections, and meters.
4. Rip out all wiring and cut interconnections of electrical equipment. Smash gas, oil, and water-cooling systems in gas-engine generators, etc.
5. Smash every electrical or mechanical part, whether rotating, moving, or fixed.
6. Break up all operating instruments such as keys, phones, microphones, etc.
7. Destroy all classes of carrying cases, straps, containers, etc.
8. Bury or scatter all debris.

DESTROY EVERYTHING!

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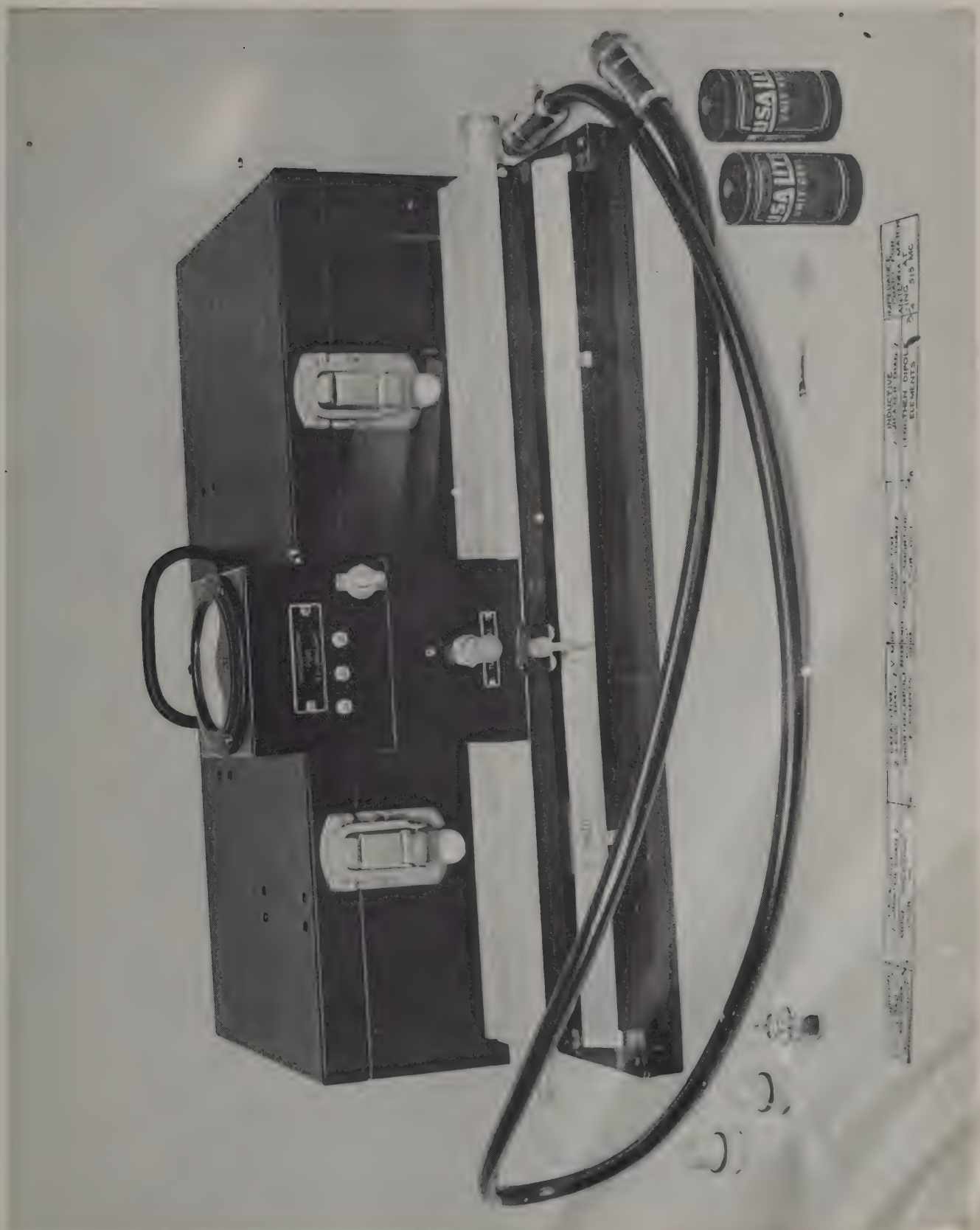

Figure 1. General View of TS-56A/AP Equipment

HANDBOOK
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SECTION I

GENERAL DESCRIPTION

1. PURPOSE OF EQUIPMENT.

a. The Model TS-56A/AP Slotted Line Test Equipment is a device primarily intended to facilitate the installation and maintenance of ASB airborne radar antennas. It can also be used for matching other antennas and in the measurement of characteristics of transmission lines, antennas and impedances.

2. FREQUENCY RANGE AND CHARACTERISTIC IMPEDANCE.

a. The Model TS-56A/AP Slotted Line is designed for operation over a frequency range of 360 to 675 megacycles. The slotted line has a characteristic impedance of 51 ohms.

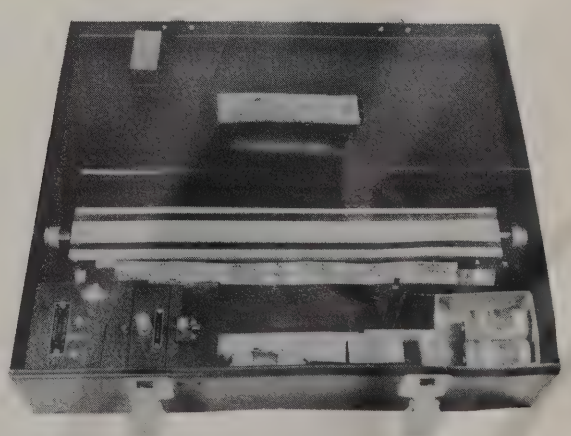


Figure 2. Equipment in Carrying Case

3. EQUIPMENT SUPPLIED AND EQUIPMENT REQUIRED.

Equipment Supplied:

Quantity	*Name of Unit*	*Overall Dimensions*	*Weight*	*Reference Symbol*
1	Slotted Line	19½" x 2¾" x 3¾"	7½ lbs.	200-29
1	Indicator Box	6" x 3½" x 3½"	3½ lbs.	100-199
1	Cable	4 ft.	1 lb.	
2	Amphenol to Selectar Adapter			
2	Spare Batteries			
1	Spare 957 Tube			
1	Spare Probe			
1	Impedance scale			
1	Spare Insulating Spacer			
1	Metal Carrying Case	5" x 8½" x 19¾"	13	

Equipment Not Supplied

Quantity	*Name of Unit*	*Required Characteristics*
1	Oscillator	Frequency same as antenna and minimum output of 2 Watts.

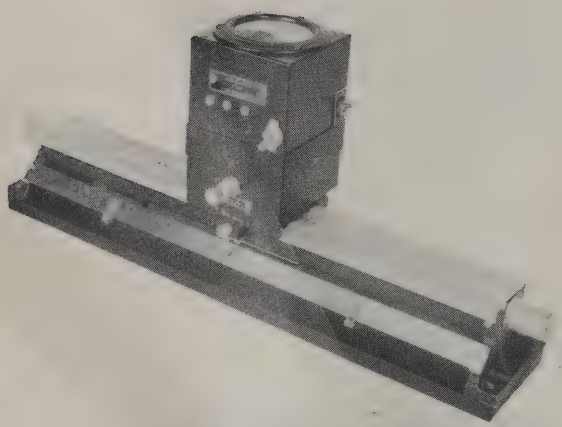


Figure 3. Slotted Line

4. GENERAL.

a. The TS-56A/AP Slotted Line is primarily intended for standing wave measurements on ASB antenna transmission lines. The oscillator normally used will be the ASB transmitter.

b. A general view of the equipment supplied is shown in Figure 1. The equipment is shipped without the battery installed in the indicator. When the equipment is to be stored or out of use for a considerable length of time, the battery should be removed and stored in the carrying case.

5. SLOTTED LINE.

a. The slotted line is a section of transmission line on which the standing wave voltage present may be measured. The voltage is picked up on an indicator through a narrow slot in the outer conductor.

6. INDICATOR.

a. The indicator consists of a detector and meter which when mounted on the slotted line indicates the voltage along the line.

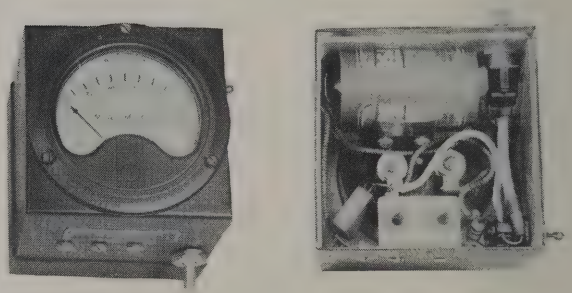


Figure 4. Indicator Box, top and bottom views

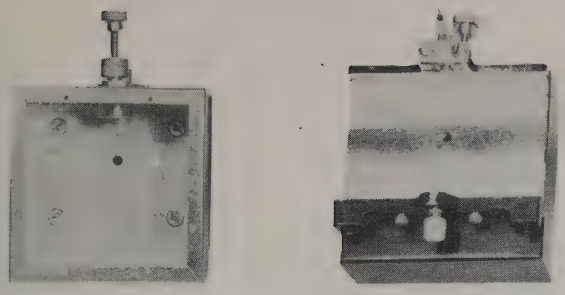


Figure 5. Resonator Box, top and bottom views. (Slider visible in bottom view)

7. CABLE.

a. The cable is a 4 ft. length of RG-8/U (formerly CASSF-50-1) with both ends terminated in Amphenol type 93-M connectors fitted with inserts. See Figure 13.

8. ADAPTER.

a. The adapter provides a means for connecting the standard type C-49195 connector with the slotted line. It consists of three pieces: the pin for the center conductor connection and the shell for the outer conductor connection, and a threaded ring.

9. IMPEDANCE SCALE.

a. The impedance scale is printed on heavy paper which may be slipped on the scale of the slotted line to indicate the condition of the load and the antenna adjustments necessary for proper matching. See Figure 16.

10. INSULATING SPACER AND PROBE.

a. The insulating spacer is a replacement part for the spacer in the end of the slotted line. The probe is a replacement part to be used on the indicator.

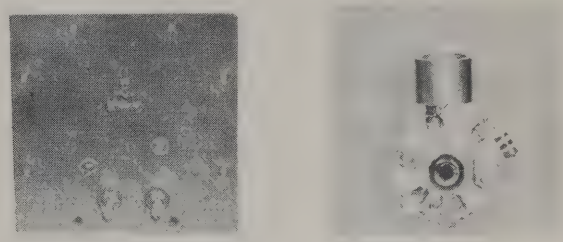


Figure 6. Resonator Top Cover: top and bottom views

SECTION II

INSTALLATION AND ADJUSTMENT

1. INSTALLATION.

a. The TS-56A/AP Slotted Line Test Equipment is connected as shown in Figure 7, for general use in standing wave measurements and determining characteristics of transmission lines, impedances and antennas.

b. Measurements with the slotted line can be made with the load connected at either end and the oscillator on the opposite end.

c. For matching antennas on ASB installations, the equipment is connected as shown in Figure 8. The standing waves on the antenna transmission lines may be measured under nearly actual operating conditions. The only departure from actual operating conditions is the presence of the slotted line and the cable in series with the antenna transmission line. The reflections introduced in the transmission line due to the presence of the slotted line equipment are negligible so that the standing wave ratio indicated may be taken as the true ratio even after the slotted line equipment is removed from the system. This condition will be true only for very short lengths of connecting cable such as supplied with the slotted line equipment.

2. ANTENNA LOCATION DURING ADJUSTMENT.

a. When adjustments are being made on aircraft antenna installations, the airplane should be outside of hangars and the antenna should be pointing into the clear. Men should not be working in front of antennas, nor should metal engines be standing near antennas.

3. CONNECTOR ADAPTER.

a. The ends of the slotted line are provided with receptacles to accommodate an Amphenol type 93-M connector. In order to use a cable equipped with a C-49195 connector, as made by Selectar and others, the "Amphenol-to-Selectar" adapter is provided.

4. ADJUSTMENTS.

a. The only adjustments required are the tuning of the indicator (see Section III, paragraph 4) and the tightening of the thumb screws on the slider to prevent radial motion of the indicator box.

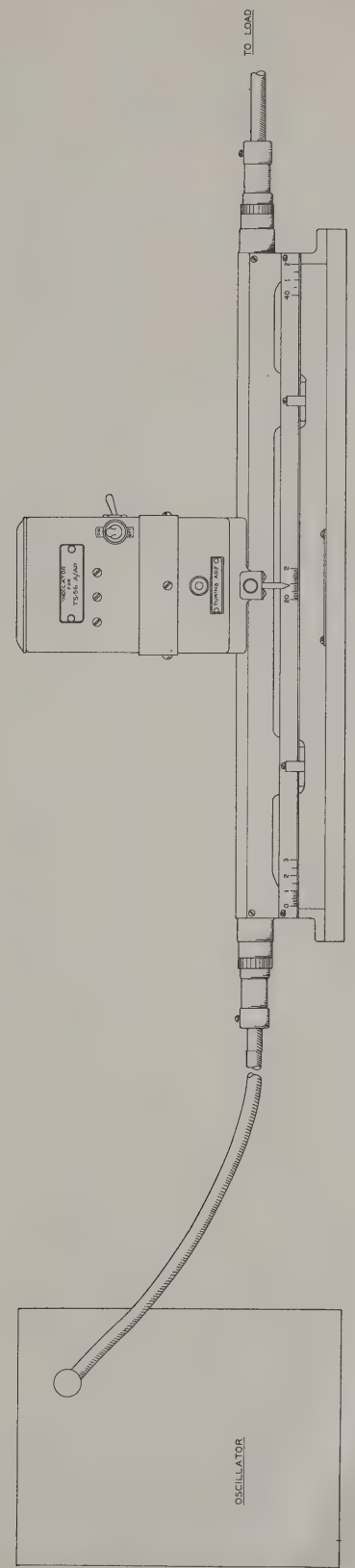


Figure 7. Equivalent Block Diagram for Impedance Measurements

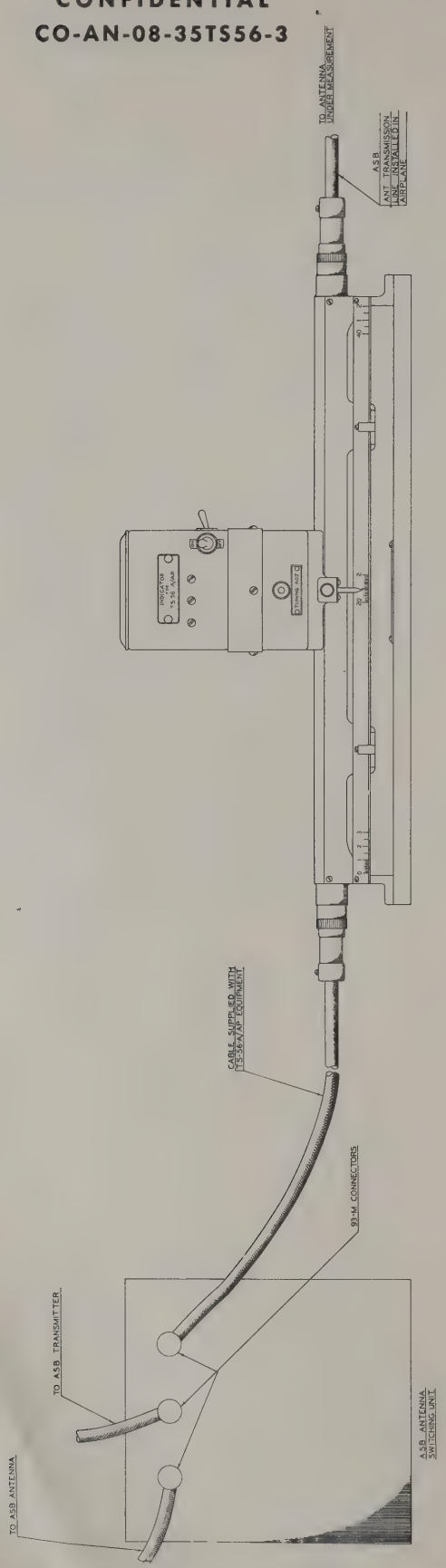


Figure 8. Connections for Slotted Line Measurements on ASB Antenna Transmission Lines

SECTION III

OPERATION

1. GENERAL USE.

a. The operation of the TS-56A/AP Slotted Line as an impedance measuring equipment will not be covered in this handbook due to the varied procedure involved. The general procedure for antenna matching is given below:

1. When an antenna is adjusted to the same impedance as the transmission line feeding it and the slotted line, the indicator reading will be virtually constant as the indicator is moved from one end of the slot to the other end. The antenna cable is then said to be "matched".

2. To match an antenna, the equipment should be connected as indicated in Figue 7. With oscillator and battery ON and the indicator tuned, the indicator is moved along the length of the slot and any variation in reading noted. The antenna is then adjusted and readjusted until the antenna is matched as indicated by the constant reading of the indicator meter when the indicator is moved along the slot.

3. In matching an antenna, a ten percent variation of the indicator reading as the indicator is moved along the line slot may be considered acceptable and further efforts to match the line is usually unnecessary. To facilitate comparison of values as the indicator is moved along the 51 Ohm slotted line, it is wise to set the maximum reading of the indicator to 100 microamperes by variation of the oscillator output. Thus a variation of indicator reading between 90 and 100 microamperes indicates a matched antenna.

2. ASB ANTENNA MATCHING.

a. The ASB radar is turned on and allowed sufficient time to warm up. Five minutes should be ample. A portable power source, such as the Waukesha Engine with aircraft type generator, or Onan Engine generator model 580-L, Onan OTC-58 series or equivalent can be used to furnish power to the ASB radar.

b. The slotted line equipment is connected as shown in Figure 8.

c. The antenna switching unit power plug is disconnected so that the switch makes contact on the antenna being matched. The position of the switch will be indicated on the ASB indicator by noting on which side of the scope the grass appears. When the switch is stopped, it may fall on neutral and no grass will appear on either side of the scope trace; momentary contact of the power plug on the antenna switching unit can be used to effect the desired positioning of the switch.

d. Keep the antennas in the homing position and point the airplane into the clear so that a minimum of strong local reflections will be present.

e. Check the frequency of the ASB transmitter. Keep within ± 1 mc. of 515 mc.

f. Take a reading on the slotted line indicator meter and adjust the tuning knob to resonance. (See Section III, paragraph 4 "Tuning the Indicator".)

g. Short circuit the transmission line at the antenna end; use preferably some sharp tool or instrument which makes a good electrical connection and also connects as closely as possible to the point of feed on the antenna (extreme end of the shorting stub).

h. Move the indicator along the slotted line until a voltage minimum is found, then attach the impedance chart to the line so that the reference point is placed exactly on the point corresponding to the voltage minimum. Do not move the chart during the remainder of the measurements.

i. Since the transmission line and the slotted line have the same surge impedance, it is merely necessary to make the adjustments on the antenna indicated by the impedance chart until the slotted line indicates a flat line. The antenna must be adjusted to within a very close tolerance so that—when varying the length of the driven element, or matching stub—great caution must be taken to make only small changes in length. These lengths are critical to within 1.0 millimeter. The procedure is as follows:

1. Remove the short from the end of the line, adjust length of driven element to 26.5 centimeters and place shortening bar in approximately the center of the matching stub.

2. Locate the new voltage minimum on the slotted line. Make adjustment to antenna as indicated on the impedance chart by the indicator pointer.

3. Check ASB transmitter frequency periodically during the matching procedure. Some isolated cases may be encountered where changes on the antenna length and bar position will cause large changes in transmitter frequency. This may happen if the transmission line is very short, but in airplane installations the transmission line is long enough so that the attenuation prevents this interaction from being troublesome. (See Section III, paragraph 3.)

4. Remember it is desirable to have both antennas present the same impedance to the transmitter so that in

switching rapidly from one antenna to the other no great variations in loading are applied to the transmitter. For this reason it is desirable to have as nearly as possible the same standing wave ratio on each of the two antennas. If after both antennas have been adjusted for minimum standing wave ratio as indicated on the slotted line, the difference in readings between the two antennas varies by a considerable amount, then the adjustment on the antenna having the best ratio should be changed to bring the two ratio values closer together.

5. After the antennas have been matched, solder shorting stub bar ends.

NOTE:

Securely solder stub and antenna; however, caution should be taken not to use excessive amounts of solder.

3. ALTERNATE METHOD.

a. An alternate method may be used when it is found that the ASB transmitter frequency shifts a considerable amount due to changes made on the antenna. Since the transmission line has a normal surge impedance of 51 ohms, the ASB transmitter will see a resistive load when connected to a transmission line which is terminated in a matched antenna (i.e., the antenna impedance is 51 ohms), and there will be no standing waves on the antenna. If a dummy load of 51 ohms resistive at 515 mc. is connected to the ASB transmitter and the transmitter frequency is adjusted to 515 mc., then any other load, such as an antenna and transmission line which is 51 ohms resistive at 515 mc. will not disturb the transmitter frequency. Also, any other load which is not 51 ohms resistive at 515 mc. may change the transmitter frequency, but its frequency will again be 515 mc. when the load is adjusted to 51 ohms resistive at 515 mc.

b. The above procedure may be carried out in practice by using the CWI-60 ADJ power and PRF meter as the dummy load. This equipment is adjusted at the factory so that the dummy load and associated cable present a resistive load of 51 ohms at 515 mc. As above, the dummy load is connected to the ASB transmitter and the transmitter frequency adjusted to 515 mc. The antenna to be matched is then connected to the transmitter and no further adjustments to the transmitter are made, but the antenna is adjusted for a minimum standing wave ratio on the slotted line. The impedance of the antenna is then approximately 51 ohms and the transmitter frequency will again be 515 mc.

4. TUNING THE INDICATOR.

a. With the oscillator set to the proper frequency for measurement and filament switch on, move the indicator along the slotted line until a peak reading is obtained and tune the resonator box by means of the screw driver adjustment marked "TUNING ADJ." on indicator (See Figure 5) until a maximum reading is obtained on the indicator. The knurled clamping nut should be unscrewed slightly before tuning and tightened after adjustment. The Model TS-56A/AP Slotted Line should be retuned for each frequency of operation.

b. In operation the indicator should be tuned as close to resonance as practicable. If the meter reads off scale on voltage maximums, the probe should be pushed into its socket slightly. If the readings are too low, the indicator may be coupled closer by pulling the probe out. At no time should the probe be allowed to touch the inner conductor as serious damage to the meter may result.

5. BATTERY TEST.

a. The battery may be tested directly by means of the switch at the side of the indicator box. An unused battery reads 75 microamperes. A reading of 40 microamperes or higher when switch is over to S.M. indicates a usable battery. The battery can only be checked with the filament switch ON.

NOTE:

To preserve life of battery, keep switch in OFF position when Slotted Line is not in use.

PART	VALUE
S-101	S.P.S.T.
S-102	D.P.D.T.
R-101	1.0 MEG.
R-102	0.1 MEG.
R-103	20000 Ω
V-101	'957
M-101	100 μa
CELL	1½ VOLTS
C-101	A-9908 & A-1260
C-102	.01 MFD.

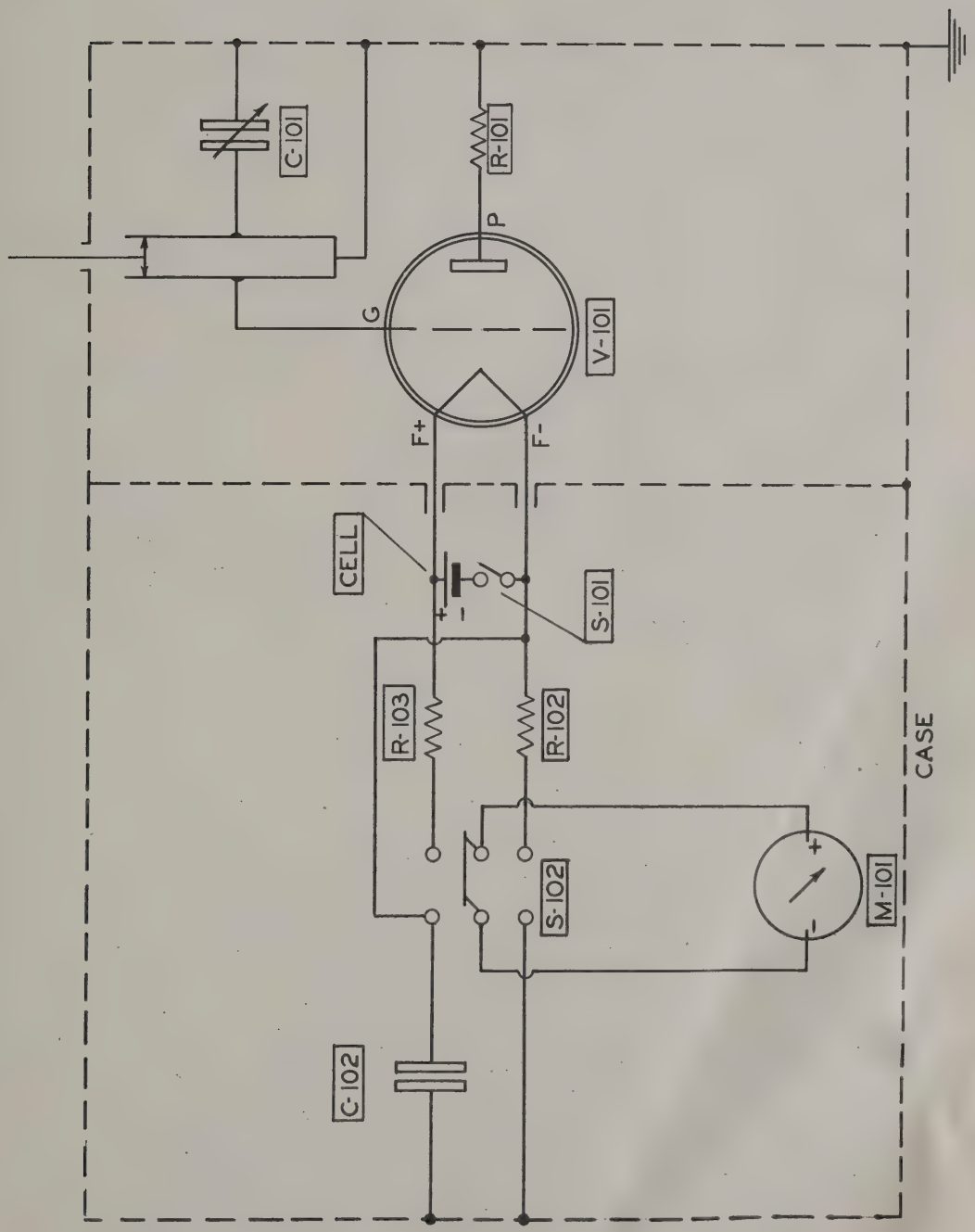
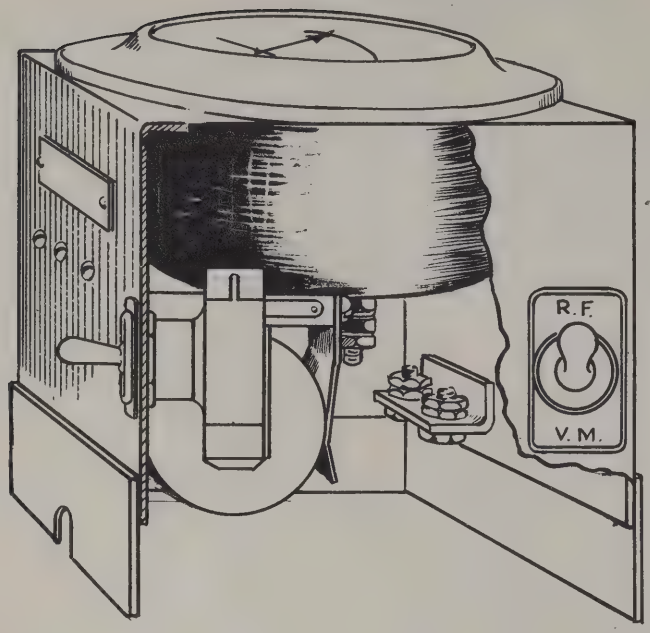
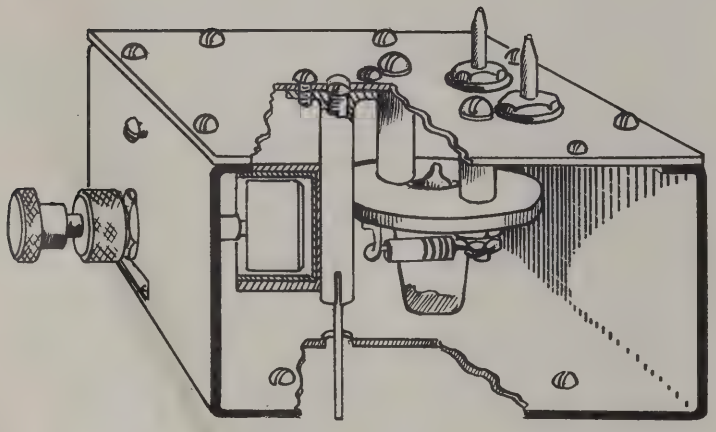


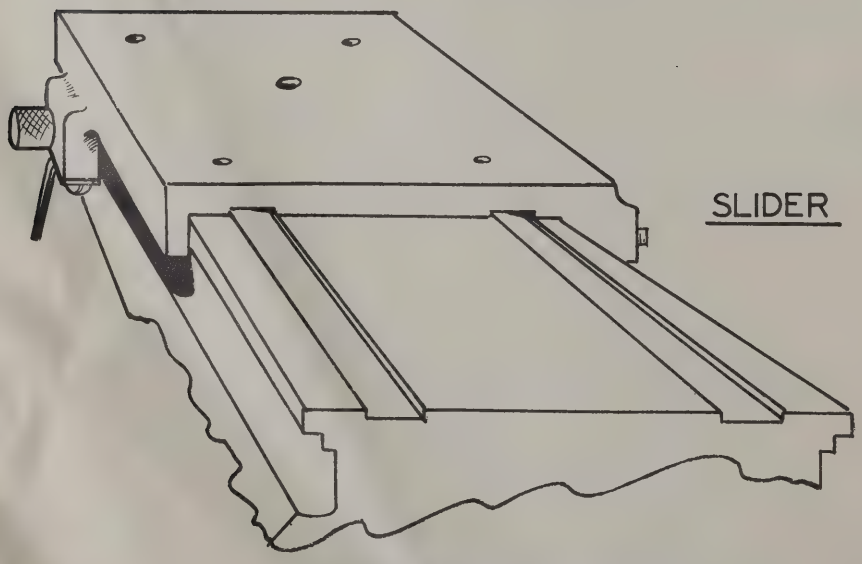
Figure 9. TS-56A/AP Schematic Diagram



METER BOX



RESONATOR BOX
& COVER PLATE



SLIDER

Figure 10. Indicator Box

SECTION IV

MECHANICAL AND ELECTRICAL CHARACTERISTICS

1. THEORY OF MEASUREMENT.

a. When energy is propagated as a high frequency wave along a transmission line such as a co-axial cable, a portion or all of the energy will be reflected back along the line unless the line is terminated in its characteristic (or surge) impedance, Zo. All of the energy will be reflected back toward the generator if the far end of the line is either short-circuited or open-circuited.

b. With a line terminated in its characteristic impedance, Zo, the voltage between the inner and outer conductors of the line will be practically constant for short lengths of line. However, an improperly terminated line will have standing waves along the line because of the reflection of energy from the improperly terminated end.

c. A transmission line is said to have standing waves along it, if the r-f voltage or curent increases and decreases as one proceeds along the line. Standing waves of voltage along an open-circuited and a short-circuited line are shown in Figure 11. In a pattern of standing waves the maximums (or minimums) are spaced one-half wavelength apart.

d. The amplitude of the standing waves is greatest when all the energy is reflected; i.e., the line is either short-circuited or open-circuited.

e. The 51 ohm Slotted Line of Model TS-56A/AP can be considered a co-axial cable. The probe (or small antenna) with the indicator is a means for measuring the potential difference or electrical field intensity between the inner and outer field conductor. The effect of the slot

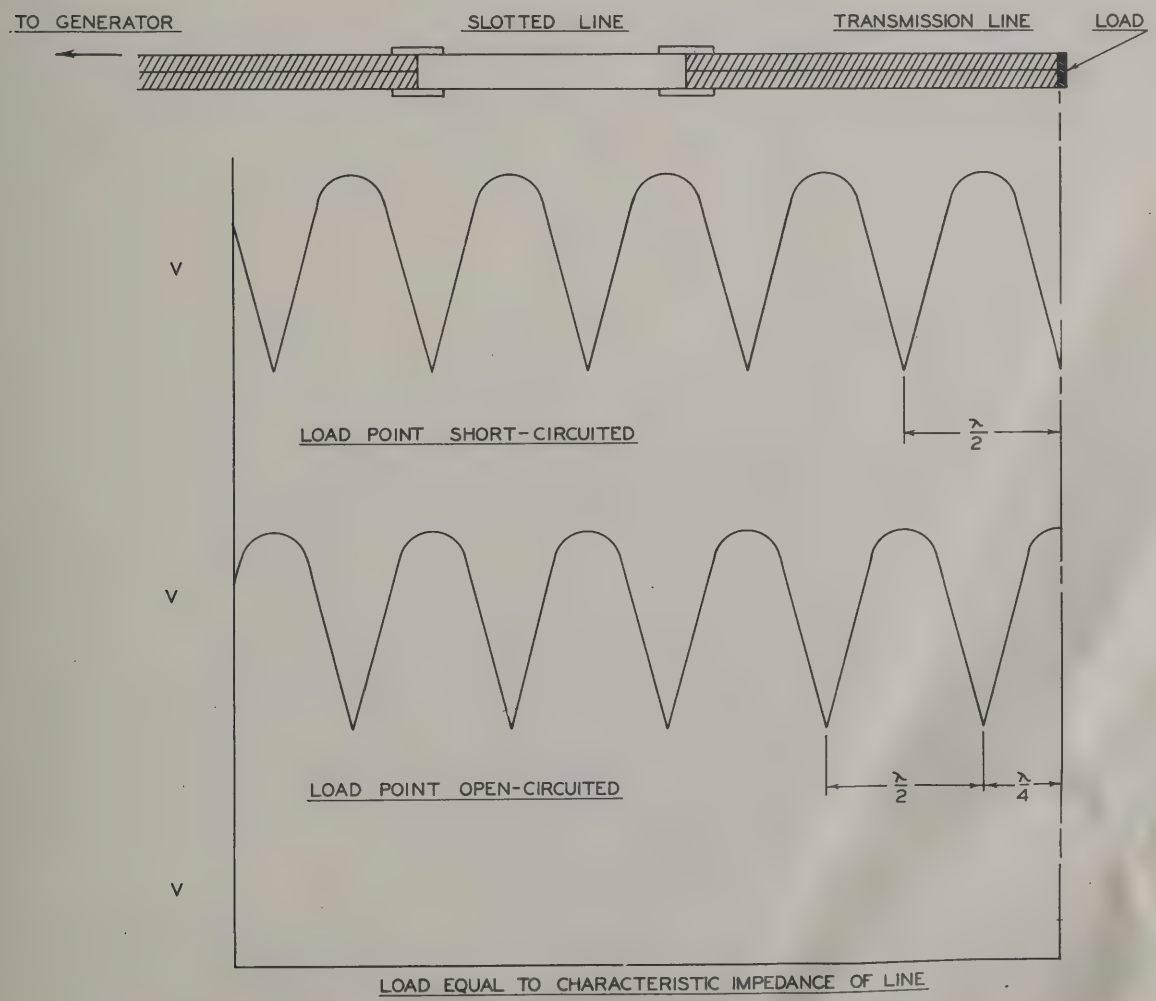


Figure 11. Variation of Voltage along a Line

in the outer conductor can be neglected since it does not disturb the electrical field appreciably.

f. Figure 12 shows the standing wave ratio for different values of terminating impedances. A standing wave ratio is the ratio of the maximum potential difference to the minimum potential difference on the line.

1. Note that at (1) when the terminating load impedance is equal to the surge impedance of the transmission line, the voltage level remains constant throughout the length of the line.

2. At (2), when the terminating load impedance is less than the surge impedance of the line, a standing wave of voltage appears on the line. At "A" the load is a short circuit, at "B", "C", and "D" the load impedance is successively increased but does not exceed the surge impedance; and at "E" the load impedance is again equal to the surge impedance.

3. At (3), standing waves again appear on the line since the terminating impedance is greater than the surge impedance. At "I", the line is open circuited, no load; at "H", "G" and "F" the load impedance is successively decreased but is always greater than the surge impedance. Again at "E" the load is equal to the surge impedance.

g. An antenna is an impedance because of its radiation resistance. This is defined as the radiated power divided by the square of the effective value of current in the antenna lead. Therefore an antenna may be used as a terminating impedance and the theory of measurement given above will apply.

2. SLOTTED LINE.

a. The slotted line has been designed to have a 51 ohm characteristic impedance by making the ratio of the inside diameter of the outer tube to the diameter of the inner rod equal to 2.342 with air as a dielectric. However, the ratio has been increased at the sections containing polystyrene spacers in order to compensate for the change in dielectric.

b. Since the length of the slot is 41.9 centimeters, no wave of wavelength greater than two times 41.9 centimeters can be used on the slotted line. This wavelength corresponds to a frequency of 358 megacycles. The slotted line has no upper frequency limit. However, the frequency limits of the complete unit are set by tuning range of the indicator box.

3. INDICATOR.

a. The indicator is divided into two separable units; the meter box and the resonator box. The meter box con-

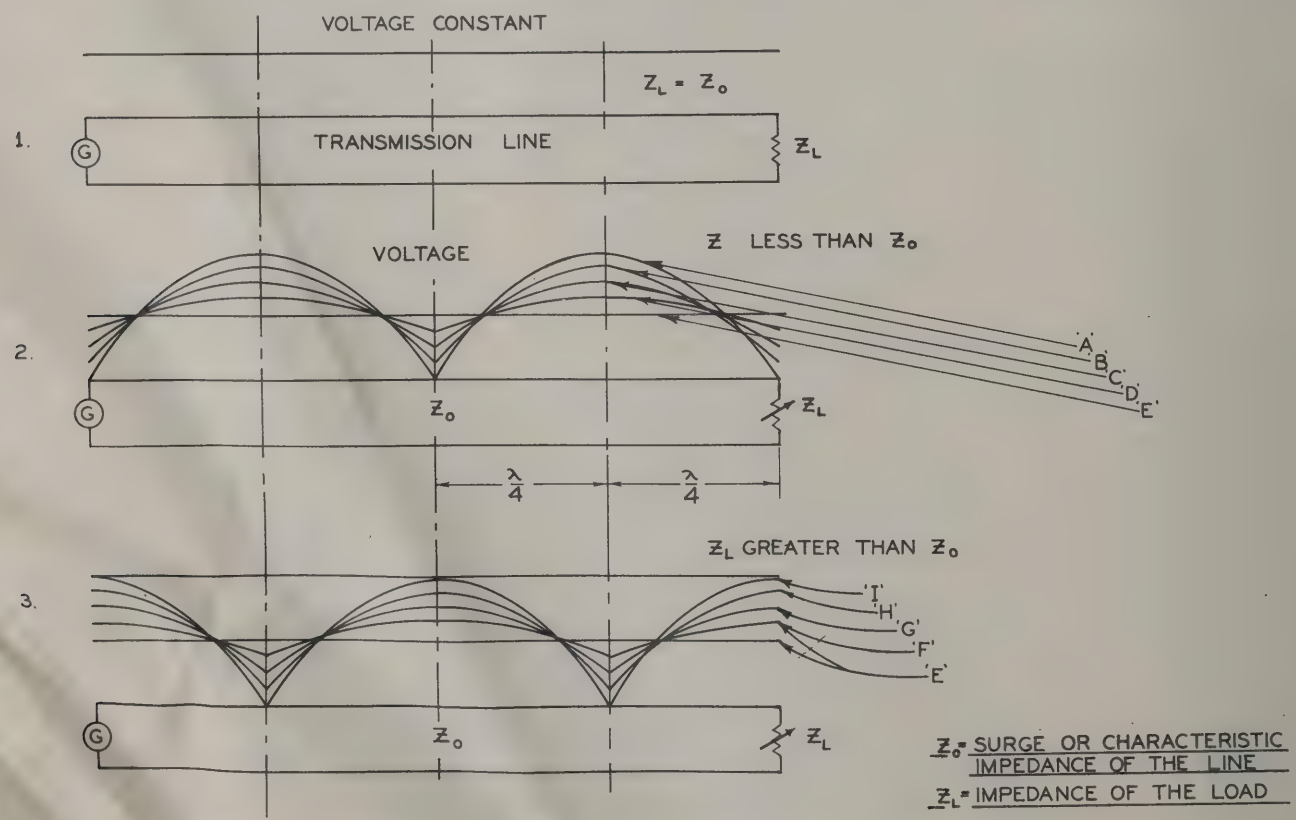


Figure 12. Standing Waves

tains the meter, battery and all wiring. The resonator box contains the 957 tube, the probe and the tuning condenser in the resonant chamber.

b. The frequency limit as set by the resonant cavity of the indicator box 340-690 megacycles.

4. CABLE.

a. The cable supplied is the RG-8/U co-axial cable terminated by two Amphenol 93-M connectors. The nominal characteristic impedance of the cable is 52 ohms. The dielectric is stabilized polyethylene and the normal overall diameter is 0.405 inches.

b. The Amphenol 93-M connectors are provided with a special insert which is in the form of a shell that makes contact with the braid and the 93-M connector (see Section V, paragraph 9). The insert maintains the cable in on position and also provides electrical continuity between the slotted line and the cable.

5. ADAPTERS.

a. Two "Amphenol to Selectar" adapters are provided for use with an Amphenol 93-F connector (on end of slotted line) and a Selectar C-49195 connector. To connect a cable with a Selectar C-49195 connector to the end of the slotted line, the adapter must be used.

b. The adapter is in the form of a shell and pin. The pin inserts into the inner connector end and the shell screws to the outer conductor of the slotted line. Selectar C-49195 connector then connects directly to the other end of the adapter.

c. The adapter is designed for 51 ohms characteristic impedance by having the ratio of the inner diameter of the shell to the outer diameter of the pin equal to 2.342 at all sections. The adapter is provided in two separate pieces because the use of a spacer such as a polystyrene would effectively change the ratio referred to above and the characteristic impedance of the adapter would no longer be 51 ohms.

6. SPACERS.

a. The polystyrene spacers in the slotted line have been designed so that characteristic impedance of 51 ohms is maintained at the section at which they are seated. However, because of the sudden change in dielectric from air to polystyrene or vice versa along the line, some reflections may be expected. The spacer thickness has been kept to a minimum to reduce the reflections which, in effect, are negligible.

NOTE:

The reflections caused by the spacer at the input end of the slotted line are not important because they do not appear on the slotted line.

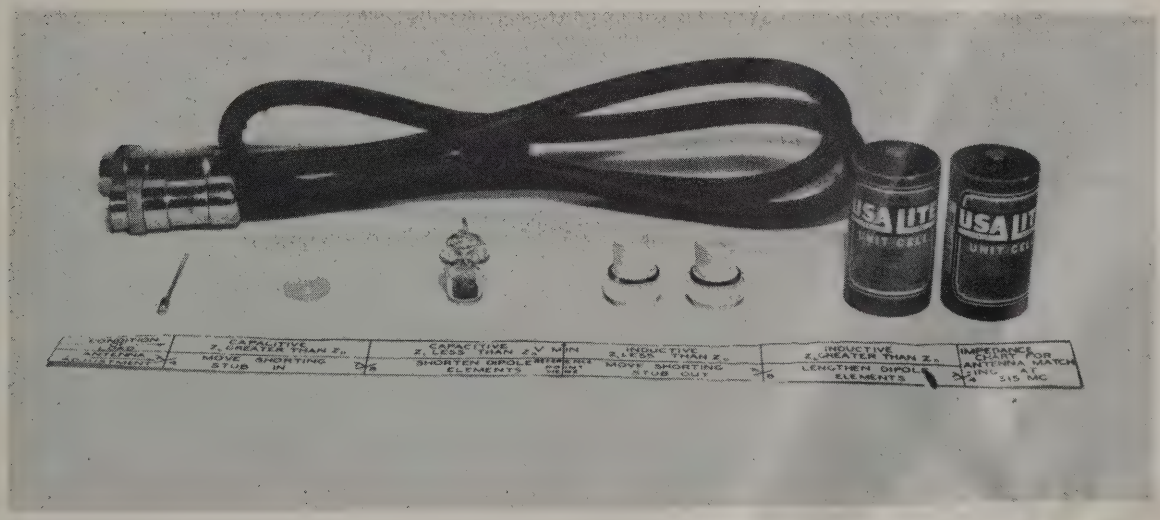


Figure 13. Components: The RG-8/U coaxial cable is in the background, the Impedance Scale in the foreground. Center (left to right) are the Probe, Spacer, 957 Acorn Tube, two Amphenol 93-M connector-adapters, and two Batteries

SECTION V

MAINTENANCE

1. HANDLING OF EQUIPMENT.

a. The Model TS-56A/AP Slotted Line Equipment is a delicate instrument requiring a high accuracy of machining. Any damage caused by twisting, dropping, bending, or overheating may affect its accuracy. Care, therefore, must be used in handling the equipment.

2. MEASUREMENT IN RAIN.

a. The slotted line should be kept clean and dry. No measurements should be made, if possible, in the rain. If the slotted line does get wet inside, it should be dried thoroughly before measurements are made.

3. PROBABLE TROUBLES.

a. If the Model TS-56A/AP Slotted Line Equipment fails to operate properly, the most likely causes will be a dead battery or defective tube. The battery should be checked first as indicated under Installation and Adjustment, Section II.

4. DISASSEMBLY OF LINE.

a. The slotted line should not be disassembled unless absolutely necessary. Figure 10 will aid in disassembling. Special tools and gauges are required in assembly of the line and it is therefore not recommended that the line be disassembled.

b. In extreme cases where it is necessary to disassemble the line the following procedure should be used.

1. First remove both outer connector ends from the line. Then unscrew one inner conductor end and pull the inner conductor out from the opposite end. One polystyrene spacer can then be easily removed from the inner conductor and the other must be removed from the outer conductor where it will be seated.

2. To assemble, the above procedure is reversed.

NOTE:

In assembling, care must be taken in handling and seating the polystyrene spacers in their proper places.

5. DISASSEMBLY OF INDICATOR.

a. The resonator box can be removed from the meter box by loosening slightly the eight binding head screws on the sides of the indicator. By unscrewing the eight screws on the bottom of the resonator box, the cover plate and slider can be removed as a unit and the 957 tube and tuning condenser in the Resonant chamber are accessible.

b. The meter may be removed from the meter box by unscrewing the three screws on the meter. It is not necessary to gain access to the clinch nuts inside the meter box.

6. REPLACEMENT OF TUBE AND BATTERY.

a. To replace the 957 tube, remove screws on cover plate at the bottom of the indicator box and replace tube. After replacement make sure the tube is in the right position with all five pins engaged by the socket lugs and the pointed end of the tube pointing into the socket.

b. The battery is accessible if the meter box is disengaged from the resonator box as explained in Section V, paragraph 5.

NOTE:

All tubes supplied with the equipment shall be consumed before use of tubes from general stock.

7. CLEANING THE LINE.

a. It is not necessary to disassemble the line for cleaning. Carbon Tetrachloride is recommended. Do not use naphtha or abrasives of any kind.

8. LUBRICATION OF SLIDING SURFACES.

a. Petroleum jelly is recommended as a lubricant for the sliding surfaces of the slotted line indicator.

9. CABLE SERVICING.

a. Directions for the fitting of 93-M Amphenol Connectors on RG-8/U cable are given in Figure 14. A special insert is used with the Amphenol connector (see Section IV, paragraph 4).

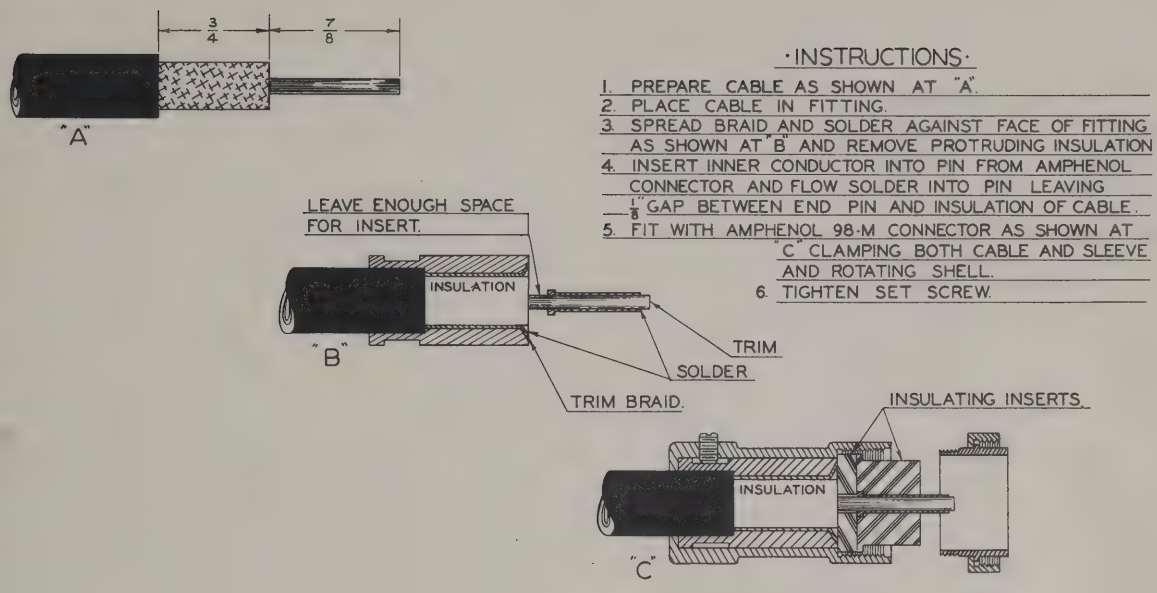


Figure 14. Cable Servicing

SECTION VI

SUPPLEMENTARY DATA

1. ADDITIONAL INFORMATION.

a. For additional information on slotted line procedure and transmission line theory, it is suggested that the instruction book on model SL-1 slotted line impedance measuring equipment be consulted.

2. INDICATOR METER CALIBRATION.

a. For ordinary antenna matching, it is not considered important that the absolute standing wave ratio be determined.

b. For determining the absolute standing wave ratio such as would be required when it is desired to measure an impedance connected to the end of the slotted line, it is necessary that the indicator meter be calibrated. Since the standing wave is a sine wave and the indicator meter does not indicate voltage changes linearly, the meter reading will not be true. A tabulation of meter readings over a full half wave, plotted as a curve when compared with a true sine wave curve will indicate the differences. From such a comparison a correction curve may be obtained so that any meter reading may be corrected.

c. However, for ordinary antenna matching it is not desired to determine the exact impedance of the antenna and hence not the standing wave ratio. It is desired only to obtain the minimum standing wave ratio. Therefore, no meter corrections are necessary.

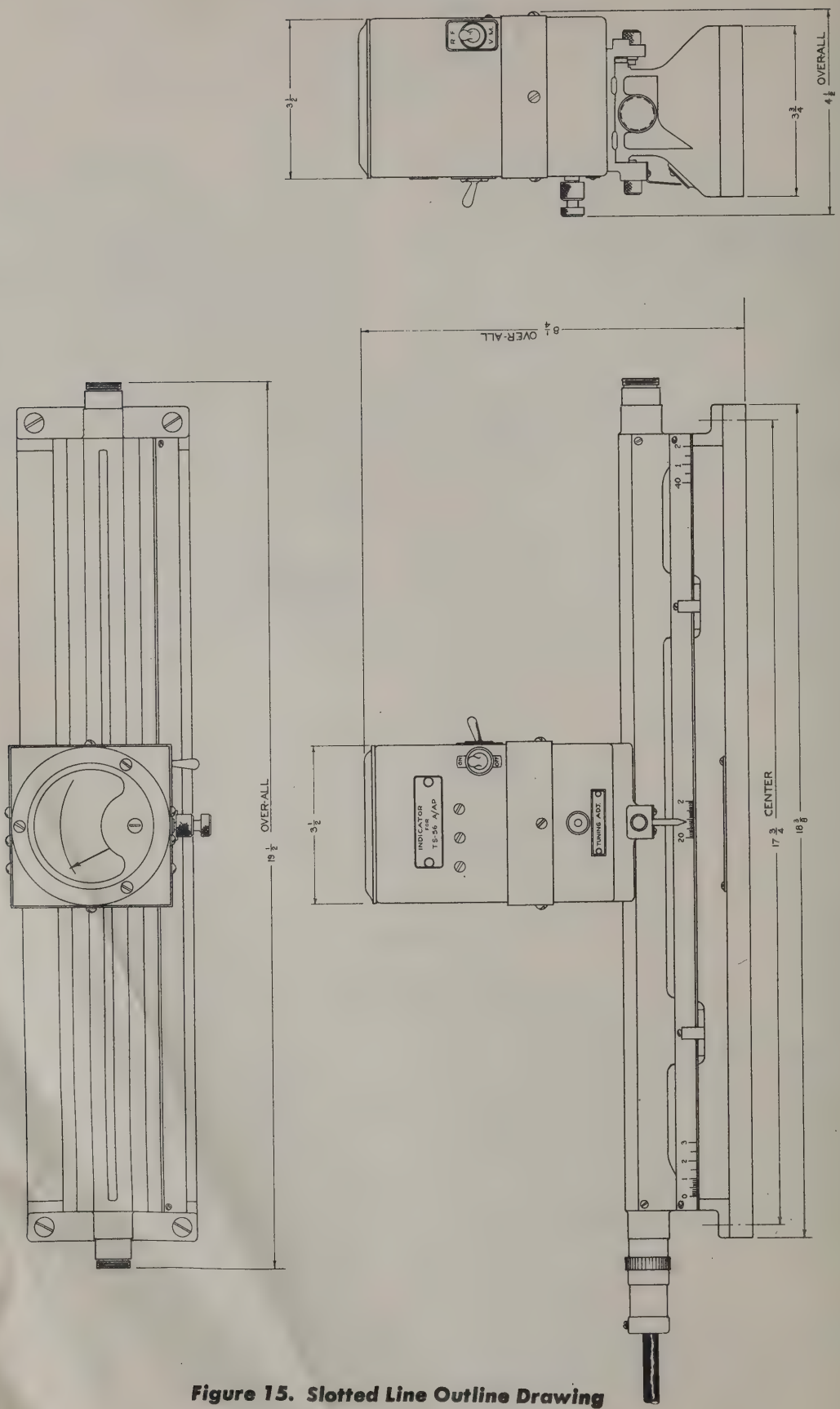


Figure 15. Slotted Line Outline Drawing

TABLE OF REPLACEABLE PARTS

Model 51 Ohm Slotted Line Equipment TS-56A/AP

Reference Symbol	*Army Stock No. Navy Type No. British Ref. No.*	*Name of Part and Description*	*Function*	*Mfr. and Desig.*	*Drawing or Spec. No.*
*B-101	17-B-7210**	BATTERY: Flashlight type; 1⅜" D; 1½V.	Filament Voltage	National Carbon Co. #950	
C-101		CAPACITOR: Variable; polystyrene dielectric; consists of a fixed hollow cylinder and a variable solid cylinder which may be made to move in or out of the hollow cylinder by means of a screw adjustable from the front of the resonator box; part of the resonator box assembly.	Tuning	Gen. Electronic Ind. B-360-D	B-360-D
C-102		CAPACITOR: Fixed; mica dielectric; 10,000 micromicrofarads, ± 20%; 300 volts D.C. working; moulded bakelite; ¾" x ¾" x ¼"; #18 tinned brass wire leads.	RF Bypass	Cornell Dubilier	1W-3S1
*E-101	No Stock No.	SPACER: Polystyrene, .062 thick .7045 overall diameter.	Spacer between inner and outer conductors at load end of line (right hand side)	G.E.I.	Drawing #A1008
E-102		SPACER: Polystyrene, .187 thick .7045 overall diameter.	Spacer between inner and outer conductors at transmitter end of line (left hand side)		#A1768
M-101		MICROAMMETER: 0-100 microamperes d-c; 3½" D.	Indicator	Westinghouse Nx-35	
R-101	(R) 16-R-17374-20	RESISTOR: Fixed; carbon; 1 megohm ± 10%, ½ W.	Plate Resistor	I.R.C. BT½	
R-102		RESISTOR: Fixed; carbon; 100,000 ohms ± 10%, ½ W.	Load Resistor	I.R.C. F ⅓	

CONTRACT OR ORDER NO. NXsa-39203
*Spare part supplied.
**Not Stocked By Aviation Supply Depots. Obtain from Navy Yards.

TABLE OF REPLACEABLE PARTS—*Continued*

Model 51 Ohm Slotted Line Equipment TS-56A/AP—*Continued*

Reference Symbol	*Army Stock No. Navy Type No. British Ref. No.*	*Name of Part and Description*	*Function*	*Mfr. and Desig.*	*Drawing or Spec. No.*
R-103	(R) 16-R-17310-88-15	RESISTOR: Fixed; carbon; 20,000 ohms ± 5%, ½ W.	Meter Multiplier	I.R.C. BT½	
S-101		SWITCH: Single pole, single throw, 3 amp., 250 V.	Battery Check	Cutler-Hammer Type 8280	
S-102	(R) 17-S-28225	SWITCH: Double pole; double throw; rear lug type; 3 amp., 250 V.	On-Off Switch	Cutler-Hammer Type 8373	
*V-101	16-T-12680*	VACUUM TUBE: Triode, acorn type; JAN-957, VT-237.	Detector	Sonotone 957	
X-101		SOCKETS: Acorn; ceramic; silver plated, beryllium copper contacts.	Mount V-101	A. W. Franklin 62A-5	

CONTRACT OR ORDER NO. NXsa-39203
*Spare part supplied.

CONDITION OF LOAD →	CAPACITIVE Z_L GREATER THAN Z_o	CAPACITIVE Z_L LESS THAN Z_o	INDUCTIVE Z_L LESS THAN Z_o	INDUCTIVE Z_L GREATER THAN Z_o	IMPEDANCE CHART FOR ANTENNA MATCHING AT 515 MC.
ANTENNA ADJUSTMENT →	MOVE SHORTING STUB IN $\lambda/4$	SHORTEN DIPOLE ELEMENTS $\lambda/8$	MOVE SHORTING STUB OUT $\lambda/8$	LENGTHEN DIPOLE ELEMENTS $\lambda/4$	

REFERENCE POINT HERE

Figure 16. Impedance Scale (Actual Size)